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EFFECT OF PROCESSING AND PREPARATION FOR SERVING ON VITAMIN CONTENT IN T, B, AND A RATION PORK

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A study was performed to evaluate and compare military serving practices for T, B, and A rations. The product for study was pork. The Tray Pack (TP) and the B ration products were sterilized in either flat or cylindrical cans. The A ration product was oven roasted. All products were subjected to various heating and holding periods to emulate military serving practices. The criteria applied to evaluate these practices was retention of vitamins B_1, B_2, and B_6 in pork before and after treatment. The results show that the retention of vitamin B_1 was usually lower than that of vitamins B_2 or B_6, regardless of the treatment. The most important factor influencing vitamin retention was the method of processing. Tray Pack processing of pork was far less destructive to vitamin B_1 than was the processing of the B ration pork in No.2½ and No.10 cans. The A ration pork processing retained a substantially greater amount of vitamin B_1 than the Tray Pack and B ration pork products.

Although wide fluctuations of F_0 values were observed during thermal processing of Tray Pack or B ration pork, thiamin loss was reasonably constant for each product replicate. These data suggested fairly uniform thermal treatment in contrast to what was indicated by the F_0

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values.

In general, military serving practices did not eppreciably effect the nutritional quality, at least with respect to vitamins B_1, B_2, end B_6.

Thiamin, Riboflavin pyridoxine.

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PREFACE

The present concept for use of Tray Packs is in the T Ration supplemented with bread/crackers, spreads, and beverages-- with all items vitamin-fortified as necessary to meet the required nutritional standards established by The Surgeon General in Army Regulation 40-25. It is anticipated that the use of the Tray Pack will increase the Army's capability to provide high quality, nutritionally adequate, hot meals to its troops in the field while significantly reducing the manpower, fuel, and water requirements of the present system.

To determine the feasibility of fortifying the Tray Packs, a study was previously conducted on the beef stew Tray Pack fortified with vitamins C, B_1, B_2, and B_6 (Project No. IL162724AH99BA028). Military field feeding was simulated and exaggerated to ascertain if additional changes would occur in nutrient content. The results showed that no significant loss occurred in the vitamins under test except for thiamin during commercial sterilization. Fortification was considered feasible and treatment of the product according to military field feeding practices was not detrimental to its nutrient content.

The present study (Project No. IL162724AH99BA029) was undertaken to compare the nutrient content of the Tray Pack with its B and A counterparts. The product, pork, was selected because it is common to all three rations even though it was recognized that the rations were not functionally equivalent.

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INTRODUCTION

The U. S. Army Natick Research, Development & Engineering Center is responsible for developing new concepts and systems relating to future logistical changes for food, clothing and shelter. Early in the 1980s, a new system concept was developed for combat field feeding that was designed to feed highly mobile tactical units, dispersed over a broad range of combat situation and locales. Current methods of preparing meals to be consumed on site or delivered to the troops in remote areas cannot be adapted to this kind of combat.[1,2] The new system aims at maximizing the use of an improved food technology for producing heat-sterilized, fully-prepared, shelf-stable foods. These foods are labeled Tray Packs and as the base of the T ration can be distributed anywhere troops are located. Not only do these foods provide the mobility and flexibility necessary to deliver high quality, hot meals in the field, but they also improve operational efficiency by reducing the need for scarce manpower resources to perform the food service function. However, a determination was required to ascertain if the new Tray Pack products would be as nutritionally adequate as the products to be replaced. For this reason, a study was initiated to compare the nutritional quality of the Tray Pack with A and B ration counterparts.

MATERIALS AND METHODS

Pork, the first product, was selected for study because it is common to all three rations - T, A, and B. It was recognized that the three rations were not functionally equivalent and that each pork component being evaluated would be a distinctly different processed pork product. However, the interest here lies in the more general comparative evaluation of the components of the three rations, each component processed according to its own method to provide the soldier with a substantial amount of the required nutrients established by The Surgeon General and specified in AR 40-25.[3]

Plans were initiated to procure sufficient raw, boneless, fresh hams to prepare all products, as follows.

(1) The T ration product was prepared according to the Interim Specification on Tray Pack Pork Slices.[4] The boneless fresh ham was prepared as a chunked and formed roll, cooked in cellulose casings, sliced, packed with gravy in Tray Pack containers, and sealed with a minimum of 10 inches vacuum. The product was then processed at 121°C to a minimum F_o value of 6.

(2) The B ration product was prepared in accordance with requirement of USDA Schedule PJ for Canned Pork chunks.[5] The boneless fresh ham was cut into chunks, ground through a 1.5-inch grinding plate, stuffed into No. 2 1/2 and No. 10 cans, and sealed with not less than 5 inches of vacuum before processing in its natural juices to a minimum F_o value of 6. The No. 10 can is not typical of the B ration for this product but

was introduced into the study because of its comparability in weight and volume to the Tray Pack.

(3) The A ration product--raw, boneless fresh ham--was cooked in a convection oven at 163°C to an internal temperature of 77°C.[6]

All containers, No. 2 1/2, No. 10, and Tray Pack were equipped with at least one thermocouple attached to the meat, prior to filling the containers. Immediately after filling, the product was vacuum-sealed and loaded into the retort for processing as rapidly as possible. Each thermocouple was connected to a data recorder (Digistrip III) to monitor and record the temperature of the product during processing and subsequent reheating. Commercial sterilization to F_o of 6 was accomplished by using only the middle shelves in four loads: one for No. 2 1/2 cans, one for No. 10 cans, and two loads for Tray Packs. After the retort was filled with water and heated to an operating temperature of 121°C, it was held at that temperature until a minimum F_o value of 6 was attained. After completion of the process, the cylindrical and flat cans were held at room temperature until further heat treatment prior to nutrient analyses. The experimental plan is outlined in Table 1.

All variables were treated in a manner to imitate their usual and extended military garrison and field feeding practices. Tray Packs were heated from room temperature to 74°C in boiling water and held unopened in insulated containers or opened in a bain marie maintained at 66°-77°F for two and three hours before analyses. Additional product

TABLE 1. Experimental Plan

Tray Pack

STEP	PROCEDURE
1	None (raw pork)
2	Commercially sterilized in Tray Pack to a minimum of F_o value of 6.0
3	Heated to 74°C in boiling water in unopened Tray Pack
4	Same as step 3, unopened Tray Pack held in prewarmed insulated container for two hours
5	Same as step 4, held for three hours
6	Same as step 3, held opened on covered bain marie 66° to 77°C for one hour
7	Same as step 6, held for two hours
8	Same as step 7, covered, refrigerated overnight, and then reheated, covered to 74°C

B RATION

1.	None (raw pork)
2.	Commercially sterilized in No. 2 1/2 cans to a minimum F_o value of 6.0
2a	Same as step 2 in No. 10 cans
3	Can contents of No. 2 1/2 can heated in open pan to 74°C
4	Opened, heated in a pan, covered, and held in prewarmed insulated container for two hours
5	Same as step 4, held for three hours
6	Same as step 4, held on covered bain marie 66° to 77°C for one hour
7	Same as step 6, held for two hours
8	Same as step 7, covered, refrigerated overnight and then reheated covered to 74°C

A Ration*

1	None (raw pork)
2	Roasted in convection oven at 163°C to an internal temperature of 77°C
5	Roasted, sliced for serving, covered, and held in prewarmed insulated container for three hours
7	Roasted, sliced for serving, and held on covered bain marie 66°to 77°C for two hours
8	Same as step 7, covered, refrigerated overnight, and then reheated covered to 74°C

*Only those procedures normally employed in A ration serving were examined. The step numerals for the procedures are comparable for TP, B, and A ration pork.

stood opened for two hours in a bain marie, was refrigerated overnight, and reheated again the next day to 74°C. The B ration products in No. 2 1/2 cans were opened, heated in a pan, covered, and then held in an insulated container or on a covered bain marie. Product in No. 10 cans received no further treatment after processing.

For the A ration product, three fresh hams were cooked for approximately 150 minutes in a convection oven at 163°C to an internal temperature of 77°C. After the roasts were removed from the oven, weighed, and allowed to cool, they were trimmed of excess fat and sliced for serving. Each of the three hams were represented in the raw sample. Due to the limited number of hams, each ham represented one treatment except for treatments in steps 5 and 7 in Table 1 (A ration), which were derived from one cooked ham.

All samples were analyzed at least in duplicate for thiamin and riboflavin. Single analyses were made for moisture and fat. For the Tray Pack, five replicates were analyzed and their means compared. For the B ration products, four replicates were analyzed and their means compared. An analysis of variance was applied, followed by statistical tests to discern significant differences among samples.[7] Moisture and fat determinations were made following the appropriate procedures described in Official Methods of Analysis.[8] Vitamin content was assayed by the methods published in Methods of Vitamin Assay[9] and values were corrected to a dry, fat-free basis.

Samples of processed pork from cylindrical (No. 2 1/2 and No. 10) and flat (Tray Pack) cans were also subjected to a punch and die test to determine the effect of commercial sterilization on texture.[10]

RESULTS AND DISCUSSION

F_o Values

Recorded temperature readings from cylindrical and flat cans allowed calculation of the F_o values each can received. The F_o values in six No. 10 cans ranged from 12.6 to 15.3; in thirty-six No. 2 1/2 cans, from 11.8 to 18.6; and in forty Tray Packs, from 6.6 to 21.7. Because of the wide variation obtained in the No. 2 1/2 cans and the Tray Packs, special care was exercised to represent this F_o range among the variables without bias. The large variation observed in F_o values could have been due to (1) improper positioning of thermocouples into cans, (2) probe sensing liquid rather than solid portion of the product, and (3) clogged jets in the retort causing the steam pressure to be uneven throughout.

The loss in thiamin (Table 2) due to processing was approximately constant (small percent S.D. of less than 3%) and was independent of the large variation (percent S.D. of over 20%) in F_o values in Tray Pack and B ration (No. 2 1/2 can) pork. Since thiamin degradation is totally dependent upon the time-temperature profile as is the computation of F_o values, it is reasonable to conclude that the internal indicator, namely thiamin, provided a better estimate of the integration of the time-temperature curve than did the external indicator, namely the thermocouple. The relatively smaller deviation (8%) of F_o values in B ration (No. 10) pork is in agreement with the explanation that the positioning of the thermocouples is extremely critical in flat Tray Packs and in small (No. 2 1/2) cans. With the larger No. 10 can, minor

TABLE 2. Thermal Processing of Tray Pack and B Ration Pork:

A Comparison of F_o and Thiamin Values.*

Tray Pack		No. 2 1/2 Cans		No. 10 Cans	
F_o	B_1**	F_o	B_1	F_o	B_1
10.1	1.26	11.3	0.920	13.1	0.293
12.4	1.27	14.6	0.931	13.0	0.284
6.7	1.28	14.7	0.922	12.6	0.286
10.1	1.29	18.6	0.958	12.9	0.300
12.5	1.33			15.3	0.280
		Mean ± S. D.			
10.4±2.4	1.29±0.027	14.8±3.0	0.933±0.017	13.4±1.1	0.289±0.008

*These represent final F_o and thiamin values at the end of processing in individual Tray Packs or cylindrical cans.

**Values are reported in mg/100 g of product. For deriving a relationship between F_o and B_1 values, it would be more appropriate to provide the loss in B_1 due to processing rather than the final remaining B_1 value. However, since the initial B_1 values are virtually constant for each product (Tables 3 and 4), this was not deemed necessary.

differences in the placement of thermocouples do not result in large fluctuations in F_o values as is the case in Tray Packs and small cans.

Texture

Several samples from the various cans were removed to measure the textural quality in terms of the amount of stress required to cause the sample to rupture using the Instron Universal Testing Instrument equipped with a Punch and Die testing probe. No measurable effect on texture due to variation in F_o values was observed, which further strengthened the conclusion drawn above.

Vitamins

The effect of serving practices as outlined in Table 1 for T, B, and A ration pork on thiamin, riboflavin, and pyridoxine content was evaluated.

Vitamin concentration is given in Tables 3, 4, and 5. These values reflect the different vitamin contents of the meat used for the T, B, and A products, as well as the vitamin concentration after the various treatments. The data in Tables 3 and 4 have been statistically analyzed and values in the same column with different letters are significantly different ($P<0.05$) from each other. Data in Table 5 could not be statistically analyzed due to the use of only one ham per treatment. Each row of Table 5 provides vitamin data for the raw ham and the corresponding roasted and treated portion of the same ham, as explained in the footnote to Table 5. The raw samples were derived from the distal portion (1 1/2" from ends) of the hams before they were roasted.

Comparison of the effect of various serving practices among the T, B, and A products can be more clearly shown when the data are normalized as shown in Table 6.

TABLE 3. Effect of Processing and Preparation for Serving on the Vitamin Content in Tray Pack Pork Slices (Flat Cans)

Treatment**		Vitamins*		
		B_1	B_2	B_6
		mg/100 g	mg/100 g	mg/100 g
Step	Procedure			
1	None (raw)	3.98 ± 0.26**	0.86 ± 0.12	2.78 ± 0.24
2	Retorted	1.29 ± 0.028	0.87 ± 0.02	1.38 ± 0.05
3	Heated to 74°C	1.25a± 0.05	0.88a± 0.02	1.36b± 0.06
		Insulated Containers		
4	Heated, held 2 h	1.17b± 0.03	0.82c± 0.02	1.46b± 0.18
5	Heated, held 3 h	1.10c±0.06	0.85b± 0.03	1.41b± 0.11
		Bain Marie		
6	Heated, held 1 h	0.97d± 0.02	0.78d± 0.03	1.59a± 0.04
7	Heated, held 2 h	0.87e± 0.04	0.79cd±0.03	1.59a± 0.03
8	Heated, held 2 h refrigerated, reheated	0.84e± 0.03	0.81c± 0.03	1.63a± 0.05

*Values in each column with different letters are significantly different ($p<0.05$) from each other.

**Mean ± S. D. of 5 replicates.

Table 4. Effect of Processing and Preparation for Serving on the Vitamin Content in B Ration Pork (Cylindrical Cans)

No. 2 1/2 Cans		Vitamins*		
		B_1	B_2	B_6
Treatment		mg/100g	mg/100g	mg/100g
Step	Procedure			
1	None (raw)	3.98 ± 0.26**	0.86 ± 0.11	2.78 ± 0.24
2	Retorted	0.93 ± 0.02	0.82 ± 0.03	1.76 ± 0.10
3	Heated to 74°C	0.86a± 0.05	0.80c±0.007	1.62b± 0.09
		Insulated Containers		
4	Held 2 h	0.75c± 0.06	0.87b± 0.04	1.49c± 0.11
5	Held 3 h	0.84ab±0.05	0.79c± 0.05	1.73a± 0.08
		Bain Marie		
6	Held 1 h	0.79bc±0.04	0.94a± 0.08	1.63b± 0.07
7	Held 2 h	0.76c± 0.02	0.88b± 0.04	1.79a± 0.08
8	Held 2 h, reheated	0.61d± 0.06	0.86b± 0.03	1.52c± 0.06
(2a)	#10 cans+	0.29 ± 0.009	0.78 ± 0.04	1.51 ± 0.08

*Values in each column with different letters are significantly different ($p<0.05$) from each other.

**Mean ± S. D. of 4 replicates.

+No further treatment.

TABLE 5. Effect of Roasting and Serving Practices of A Ration Pork on Vitamins B_1, B_2, and B_6.*

RAW					ROASTED				
Step	Treatment	B_1	B_2	B_6	Step	Treatment	B_1	B_2	B_6
		mg/100 g					mg/100 g		
1	None	3.09	1.21	2.57	2	Roasted	2.35	1.11	1.81
1	None	6.68	1.16	2.91	5	Roasted, sliced for serving, covered and held 3 h in insulated container.	2.69	1.08	1.39
1	None	6.68	1.16	2.91	7	Roasted, sliced for serving and held on a covered bain marie for 2 hrs.	2.79	1.12	1.46
1	None	2.64	1.15	2.82	8	Same as 7, covered, refrigerated overnight and reheated, covered to 74°C.	1.17	0.89	1.40

*Steps corresponding to those described in Table 1. The front and end piece of the three hams were cut and homogenized providing three replicates. The individual values for each of the hams are shown on the left side under RAW. Due to the limited number of hams, each ham represented one treatment, except for treatment in steps 5 and 7, which were derived from one cooked ham (compare the left RAW and right ROASTED side of each row).

The retention of thiamin was usually lower than that of riboflavin or pyridoxine, regardless of the treatment. The most important factor influencing vitamin retention was the method of sterilization or roasting. In general, military serving practices did not appreciably influence the nutritional quality, at least with respect to vitamins B_1, B_2, and B_6.

Oven roasted pork (A ration) retained more thiamin than retorted pork (Tray Pack, B ration). There was more thiamin remaining in Tray Pack pork than that in either No. 2 1/2 or No. 10 cans, representing the B ration. Only 7% thiamin was retained in the pork processed in the No. 10 can. The retention of thiamin in the Tray Pack pork (32%) was greater than that in the pork processed in the No. 2 1/2 can (23%). This result was expected since the tray configuration allows faster heat penetration and shorter time to reach the appropriate F_o value than the No. 10 can, the phenomenon having been demonstrated in previous studies.[11]

Influence of Treatments

Vitamin retention in subsequent treatments has been based on the amount of the vitamin present in the initial unprocessed raw pork products.

As described earlier in Table 1, the roasted pork was sliced while hot and, therefore, it was not necessary to heat this product further before holding it in an insulated container or placing it on a covered bain marie. Intact Tray Packs were submerged in boiling water and heated to 74°C. B ration pork in No. 2 1/2 cans was opened and the contents transferred to an open pan and heated to 74°C. There was no appreciable

TABLE 6. Effect of Various Treatments on Vitamin Retention in Military Pork Products*

	TREATMENTS	TRAY PACK			B RATION(2 1/2)			B RATION(10)			A RATION		
STEP	PROCEDURE	B_1	B_2	B_6	B_1	B_2	B_6	B_1	B_2	B_6	B_1	B_2	B_6
1	None	100	100	100	100	100	100	100	100	100	100	100	100
2	Sterilized Roasted	32	101	50	23	95	63	7	91	54	76	92	70
3	Heated to 74°C	31	102	49	22	93	58	-	-	-	-	-	-
4	Same as 3, held for 2 h in insulated container	29	95	53	19	101	54	-	-	-	-	-	-
5	Same as 4, for 3 h	28	99	51	21	92	62	-	-	-	40	93	48
6	Same as 3, held on Marie Bain for 1 h	24	91	57	20	109	59	-	-	-	-	-	-
7	Same as 6, held for 2 h	22	92	57	19	102	64	-	-	-	42	97	50
8	Same as 7, refrigerated to 74°C	21	94	59	15	100	55	-	-	-	44	77	50

*See Table 1 for more detailed information on procedures employed. Values given are percent retention, i.e., expressed as percentage of respective initial unprocessed raw pork products.

change in vitamin retention of the reheated samples except that the vitamin B_1 retention in the B ration product was lower than that in the Tray Pack pork (Table 6, Step 3). This observation is attributed to the presence of oxygen in the B ration product, which was exposed to air in an open pan while being heated to 74°C. The Tray Pack pork was heated in an enclosed container.

After the products reached 74°C, they were either placed as is (Tray Pack) or covered (B ration) in an insulated container for 2 or 3 hours, or held in a covered bain marie for 2 hours followed by overnight refrigeration and reheating to 74°C. The Tray Pack data show that thiamin retention decreased as the holding time increased and that holding the product on the bain marie was more detrimental to thiamin retention than holding the product in an insulated container. This can be attributed to the heating treatment in the bain marie as opposed to the mere holding treatment in the insulated container.

Some of the enhancement seen in B ration data for riboflavin is most likely due to fluorescent compounds generated by the protein-carbohydrate browning interactions. In this study, pyridoxine assays have not been reliable due to lack of reproducibility in the standard curve from assay to assay. Therefore, only major trends in the pyridoxine data should be considered. In no case was the retention sufficiently low to be considered an impairment to its riboflavin or pyridoxine content.

In this study, roasted pork (A ration) retained more thiamin and pyridoxine than the Tray Pack or B ration products. No difference in

riboflavin retention was obtained among any of the three products. However, it has to be emphasized that the data for the A ration is based upon one sample. Because each treatment represented a different ham, it is difficult to derive any major conclusions as to the effect of the treatments upon vitamin retention in roasted hams.

CONCLUSIONS

The following conclusions are supported by the results of this study.

a. The processing treatments were far more destructive to heat labile vitamins than the subsequent serving practices.

b. Tray Pack ration pork processing was beneficial in retaining more thiamin than the B ration processing of pork in either No. 2 1/2 or No. 10 cans.

c. Holding pork in insulated containers was less detrimental to its thiamin retention than using a covered bain marie to hold the product warm for servings.

d. There was little or no effect on the riboflavin retention in pork regardless of the processing method or the subsequent heating and holding treatments.

e. In general, military serving practices did not appreciably influence the nutritional quality of Tray Pack, B, and A ration pork, at least in regards to the water soluble vitamins -- thiamin, riboflavin, and pyridoxine.

f. Thiamin degradation during processing did not correlate with F_o values in Tray Pack and B (No. 2 1/2 cans) ration pork. The data question the validity of F_o values obtained during processing of Tray Pack and B (No. 2 1/2 cans) ration pork using thermocouple probes.

RECOMMENDATIONS

It is recommended that:

1. Development and use of Tray Pack components should be expedited in lieu of items processed in cylindrical cans.

2. Tray Packs should continue to be held in insulated containers rather than on bain marie for optimum nutritional quality.

3. The time for maintaining food at serving temperature be as short as possible.

4. Additional studies under comparable conditions be made to investigate other classes of foods.

5. Comprehensive studies be conducted to correlate F_o values with other internal indicators, and procedures should be established to minimize large fluctuations in F_o values from can to can during thermal processing.

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